I CLAIM:

1. A method of making a heat-resistant article of manufacture comprising:

providing a first body of a first solid material having a first exposed surface thereon;

providing a second body of a second solid material having a second exposed surface thereon;

establishing a contact region between said second exposed surface and at least one part of said first exposed surface; and

supplying a heat-resistant composite at said contact region to bond the at least one part of said first exposed surface to said second exposed surface at said contact region;

said composite comprising a composite matrix and a plurality of non-segregating reinforcing elements substantially uniformly dispersed therein.

2. The method as in claim 1 including stably and uniformly distributing said non-segregating reinforcing elements in said composite matrix.

3. The method as in claim 1 including causing said composite to have a thermal conductivity which is significantly higher than that of said composite matrix.

4. The method as in claim 1 including causing said composite to have a thermal conductivity which is at least 30% higher than that of said composite matrix.

5. The method as in claim 1 including causing said composite to have an anisotropic thermal conductivity with the maximum thermal conductivity oriented in a selected direction.

6. The method as in claim 1 including causing said composite to have an electrical conductivity which is significantly higher than that of said composite matrix.

7. The method as in claim 1 including causing said composite to have an electrical conductivity which is at least 30% higher than that of said composite matrix.

8. The method as in claim 1 including causing said composite to have an anisotropic electrical conductivity with the maximum electrical conductivity oriented in a selected direction.

9. The method as in claim 1 wherein:

said reinforcing elements are solid reinforcing elements; and

at least a majority of said solid reinforcing elements are selected from the group consisting of solid powders, hollow powders, solid fibers, hollow fibers, and combinations thereof.

10. The method as in claim 1 wherein:

said reinforcing elements are solid reinforcing elements;

said composite matrix is a liquid having a specified density; and

each of said reinforcing elements has an average density which is substantially equal to said specified density to ensure a stably non-segregating quality of said solid reinforcing elements in said liquid composite matrix thereby forming said solid-reinforced composite in a liquid form.

11. The method as in claim 10 including:

mixing said solid reinforcing elements in said liquid composite matrix to form said heat-resistant composite in a substantially uniformly distributed liquid suspension; and

freezing said liquid-suspended solid-reinforced composite in a condition to keep said solid reinforcing elements in the same substantially uniformly distributed form.

12. The method as in claim 11 wherein:

said composite matrix consists essentially of a metal or an alloy thereof; and

said solid-reinforced composite is a metal-matrix composite.

13. The method as in claim 1 wherein said first body comprises a first part of an equipment and said second body comprises a second part of said equipment.

14. The method as in claim 13 wherein said composite is a bonding composite which bonds said first body to said second body at the contact region on said equipment.

15. The method as in claim 14 wherein said equipment is selected from the group consisting of automobile, computer, jet engine, electronic circuit assembly, and aerospace structure.

16. A method as in claim 15 wherein:

said first body has a coefficient of thermal expansion which is at least 100% greater than that of said second body; and

said equipment is subjected to at least a plurality of thermal cycles over a temperature range of at least -20 to 200°C causing a significant thermal mismatch stress in said composite at said contact region which would fail a conventional solid-reinforced composite with segregated reinforcing elements but is tolerable with the solid-reinforced composite with said substantially non-segregating solid reinforcing elements.

17. A method of making a heat-resistant equipment comprising:

providing an equipment having a frame;

providing an electronic circuit board rigidly mounted with a significant mounting stress applied onto, and at a designated contacting region on, said frame;

said circuit board having a plurality of electronic circuit components fusion-bonded thereon;

said circuit board consisting essentially of a ceramic or plastic board with a top major surface having a plurality of designated bonding regions for fusion-bonding said plurality of electronic circuit components; and

supplying a fusible metal-matrix bonding composite, which comprises a composite matrix and a plurality of refractory reinforcing elements substantially uniformly and stably dispersed therein, for fusion-bonding said plurality of circuit components;

said mounting frame, circuit board, and fusible metal-matrix composite at least comprising materials which, from one another, differ significantly in coefficients of thermal expansion to thereby produce significant thermal mismatch stresses at said bonding or contacting regions;

said substantially uniformly and stably dispersed, refractory reinforcing elements in the bonding composite providing heat resistance to the bonding regions between the circuit components and the circuit board and, despite a combined presence of said mounting stress and said thermal

mismatch stress at said various bonded or mounted regions, making the equipment frame, the circuit board, and the circuit components heat-resistant.

18. A heat-resistant article of manufacture comprising:

a first body of a first solid material having a first exposed surface thereon;

a second body of a second solid material having a second exposed surface thereon;

at least one part of said first exposed surface being in close proximity with said second exposed surface to thereby form a contact region therebetween; and

a heat-resistant composite at said contact region to bond the at least one part of said first exposed surface to said second exposed surface at said contact region;

said composite comprising a composite matrix and a plurality of substantially non-segregating solid reinforcing elements substantially uniformly dispersed therein.

19. An article of manufacture as in claim 18 in which said solid reinforcing elements are selected from the group consisting of solid powders, hollow powders, solid fibers, hollow fibers, and combinations thereof.

20. An article of manufacture as in claim 18 in which:

said composite matrix is a liquid having a specified density; and

each of said reinforcing elements has an average density which is substantially equal to said specified density to ensure a substantially non-segregating quality of said solid reinforcing elements in said liquid composite matrix thereby forming a solid-reinforced composite in a stable liquid suspension form.

March 29, 2001

RICK JORDAN
PSF 188
ARLINGTON,VA 22202

This is to inform you that the document requested in your order dated 03-23-2001 is a true reproduction of the official office record copy of that document:

09053741 CERTIFIED PAT APP AS FILED-EXPEDITE-PSF 1

PAGE 54 MISSING

- [x] The enclosed Patent Application as Filed is a reproduction of the application as originally filed and has been recorded using high quality scanning or microfilm equipment. Copies of page/papers that were not scannable have not been included, nor have pages/papers received after the original filing date. Copies of these pages/papers may be ordered separately.

- [ ] The enclosed document is a reproduction of the best available source of the official office record copy of that document.

If you have any questions or need additional information, please contact our Customer Service Department.

Mailing Address:
U.S. Patent and Trademark Office
Office of Public Records, Customer Service
Crystal Gateway 4, Suite 300
Washington DC 20231

Delivery Address:
U.S. Patent and Trademark Office
Office of Public Records, Customer Service
1213 Jefferson Davis Highway, Suite 300
Arlington VA 22202

For faster processing of new orders, please specify as appropriate:
Box 9 (Copy Sales) for Uncertified copies, or Box 10 for Certified copies of PTO Documents

Voice: (703) 308-9726 Fax: (703) 308-7048 E-Mail: PTCS@USPTO.GOV or Certdiv@USPTO.GOV

Ref:PS 384035

21. An article of manufacture as in claim 20 in which:

the plurality of said solid reinforcing elements substantially uniformly dispersed in said liquid composite matrix is subsequently frozen in a condition to maintain said solid reinforcing elements in the same substantially uniformly dispersed form in said composite matrix.

22. An article of manufacture as in claim 18 in which:

said composite matrix consists essentially of a metal or an alloy thereof; and

said solid-reinforced bonding composite is a metal-matrix composite.

23. An article of manufacture as in claim 18 in which:

said first body comprises a first part of an equipment and said second body comprises a second part of said equipment;

said bonding composite bonds said first body to said second body.

24. An article of manufacture as in claim 23 in which said equipment is selected from the group consisting of an automobile, a jet engine, a computer, an electronic circuit assembly, and an aerospace structure.

25. An article of manufacture as in claim 23 in which:

said first body has a coefficient of thermal expansion which is at least 100% greater than that of said second body; and

said equipment is subjected to at least a plurality of thermal cycles over a temperature range of at least -20 to 200°C producing a significant thermal mismatch stress in said composite at said

contact region that would fail a conventional solid-reinforced composite with segregated reinforcing elements but is tolerable with the solid-reinforced composite with non-segregating reinforcing elements.

26. A heat-resistant equipment comprising:

an equipment having a mounting frame and an electronic circuit board rigidly mounted, with a significant mounting stress, at a designated contacting region on the frame;

said circuit board consisting essentially of a ceramic or plastic board with a top major surface which has a plurality of designated bonding regions for locating thereat a plurality of electronic circuit components; and

a fusible metal-matrix bonding composite comprising a composite matrix and a plurality of solid refractory reinforcing elements substantially uniformly and stably dispersed therein;

said bonding composite fusion-bonding said plurality of circuit components onto the top major surface of said circuit board at said designated bonding regions;

said mounting frame, circuit board, and bonding composite having materials which, among one another, differ significantly in coefficients of thermal expansion to thereby introduce a significant thermal mismatch stress at said bonding or contacting regions;

said substantially uniformly and stably dispersed, solid refractory reinforcing elements in the bonding composite providing heat resistance to the bonding regions between the circuit components and the circuit board and, despite a combined presence of said mounting stress and said thermal mismatch stresses at said various bonding or contacting regions, making said equipment in its entity including the mounting frame, the circuit board, and the circuit components heat-resistant.

27. A method of making substantially non-segregating solid reinforcing elements for suspension in a liquid bonding composite matrix of a preselected liquid density d_m for use in a heat-resistant equipment, said equipment containing a plurality of electronic circuit components mounted or bonded on an electronic circuit board on said equipment, comprising:

supplying for each of a plurality of said solid reinforcing elements a respective solid inner core material of a selected shape and having a preselected average volume v_1, a preselected average density d_1 and a preselected average weight w_1;

providing on each of said respective inner core material a respective solid outer shell material having a preselected average volume v_2, a preselected average density d_2 and a preselected average weight w_2; and

adjusting the values of v_2 and v_1, so that each of said reinforcing elements has an average weight of $v_1 d_1 + v_2 d_2$ which is substantially equal in weight to that of a volume $v_1 + v_2$ of said liquid bonding composite matrix having said preselected liquid density d_m to thereby achieve a substantially non-segregating quality of said solid reinforcing elements when suspended in said liquid bonding composite matrix, thereby forming a solid-reinforced bonding composite containing said plurality of reinforcing elements substantially uniformly distributed in said composite matrix in a liquid suspension form.

28. The method as in claim 27 including solidifying said liquid bonding composite suspension containing said substantially non-segregating solid reinforcing elements therein under a condition sufficient to achieve said substantially uniform distribution of said solid reinforcing elements in said solidified bonding composite.

29. The method as in claim 28 including:

providing a composite mold having a specified internal shape for the liquid composite suspension to freeze therein; and

introducing said liquid composite suspension into said composite mold; and

solidifying said liquid composite suspension whereby the solidified solid-reinforced composite has the same outer shape as the internal shape of said liquid composite mold.

30. The method as in claim 29 wherein:

the specified internal shape of said composite mold is in the form of a donut-shaped space between an outer cylinder and an inner rod generally concentric to said outer cylinder; and

including causing said liquid composite suspension to freeze in said composite mold to thereby at least form a frozen, generally cylindrical solid composite tube.

31. A method of making a heat-resistant metal-matrix composite comprising:

supplying a matrix of a metal or an alloy thereof;

providing a plurality of substantially non-segregating, solid reinforcing elements; and

stably dispersing the plurality of said solid reinforcing elements substantially uniformly in said metal matrix to form a metal-matrix composite;

said non-segregating reinforcing elements consisting essentially of a material significantly more heat-resistant than said composite matrix to thereby make the resultant metal-matrix composite also heat-resistant.

32. The method according to claim 31 including providing a composite mold having a specified internal shape for the liquid composite suspension to freeze therein; and

introducing said liquid composite suspension into said composite mold to thereby solidify said liquid composite suspension so as to assume the internal shape of said composite mold whereby the solidified solid-reinforced composite has the same outer shape as the internal shape of said liquid composite mold.

33. The method according to claim 32 wherein:

the specified internal shape of said composite mold is in the form of a donut-shaped space between an outer cylinder and an inner rod generally concentric to said outer cylinder; and

including causing said liquid composite suspension to freeze in said composite mold to thereby at least form a frozen, generally cylindrical solid composite tube.

34. A heat-resistant metal-matrix composite comprising:

a matrix of a metal or an alloy thereof; and

a plurality of substantially non-segregating, solid reinforcing elements stably dispersed substantially uniformly in said metallic matrix thereby forming a metal-matrix composite;

said non-segregating reinforcing elements consisting essentially of a material significantly more heat-resistant than said composite matrix to thereby make the resultant metal-matrix composite also heat-resistant.

35. A composite as in claim 34 in which said solid reinforcing elements provide mechanical reinforcement to thereby significantly increase mechanical strength of said metal-matrix composite.

36. A composite as in claim 34 in which said solid reinforcing elements provide thermal reinforcement to thereby significantly increase thermal conductance of said metal-matrix composite.

37. A composite as in claim 34 in which said solid reinforcing elements provide electrical reinforcement to thereby significantly increase electrical conductance of said metal-matrix composite.

38. A composite as in claim 34 in which said solid reinforcing elements provide both mechanical and thermal reinforcement to thereby significantly increase both mechanical strength and thermal conductance of said metal-matrix composite.

39. A composite as in claim 34 in which said solid reinforcing elements provide mechanical, thermal, and electrical reinforcement to thereby significantly increase mechanical strength, thermal conductance, and electrical conductance of said metal-matrix composite.

40. A composite as in claim 34 in which said solid reinforcing elements provide reinforcement to the metal-matrix composite to thereby significantly improve at least one physical property selected from the group consisting of mechanical property, thermal conductance, electrical conductance, and heat resistance; and

41. A composite as in claim 40 in which said at least one property is anisotropic and oriented in a selected direction.

42. The method according to claim 31 wherein said solid reinforcing elements consist essentially of a reinforcing material which has a density within 10% of that of said metal matrix in a liquid form; and said metal matrix consists essentially of a lead-free alloy having a melting point no more than about 300°C.

43. The method according to claim 31 wherein:

said sollid reinforcing elements consist essentially of a reinforcing material which is selected from the group consisting of a single metal, an alloy of a metal, and a mixed or collected mineral or rock not artificially processed except for selecting, sorting, surface clearning and packaging.